



**Third United Nations
International Conference
on the Peaceful Uses
of Atomic Energy**

A/CONF.28/A/346
USSR

February 1964

Original: RUSSIAN

Confidential until official release during Conference

Abstract

EXTRACTION PROCESSES AND THEIR MATHEMATICAL DESCRIPTION

A.M. Rosen, V.G. Yurkin et al.

The present work was undertaken to investigate and quantitatively interpret the regularities of extraction processes: extraction equilibria, material distribution in multi-stage radiochemical extractors, mass-transfer processes.

a. The equilibrium study includes the investigation of the effects of extractant composition and structure, salting-out-agent and diluent influence on the extraction of some actinides by neutral phosphororganic compounds.

An attempt was made to establish the quantitative relationship between the extractability and the solvent structure. The free energy for the extraction of actinides was found to depend approximately linearly on the effective electronegativity sum of functional groups, forming part of the extractant.

The extraction specific feature, i.e. a relatively weak basic chemical interaction between the extracted species and the extractant requires that contribution of both the electrostatic and Vanderwaals' interactions to the chemical potential should be taken into account, i.e. the solution theory should be used. Thus, taking into consideration the electrostatic forces and hydration in terms of electrolyte solution theory, it is possible to interpret theoretically and describe quantitatively the effect of salting-out-agents (it being sufficient to know the ionic diameter and hydration numbers of the compound and salting-out-agent).

The quantitative description of the diluent effect is attained using the theory of multicomponent non-electrolyte solutions. The necessity to consider pair interactions between all the components of the organic phase (dissolvent, extractant, metallic solvate, water, HNO_3) is revealed. The Translation provided by courtesy of the submitting Government

interactions are investigated by measurements of the activity coefficients in binary systems. Physicochemical interpretation of the deviations observed from the ideality and their influence on the extraction are given.

b. Extraction cascade regularity study includes techniques for the calculation of material distribution on cascade stage, the determination of recovery and decontamination in the extractors, having different flow-sheets and with combination of an extraction performance and the optimization methods are discussed; it is shown that the influence of change of different parameters (flow, concentration) can be described in terms of a variation of one generalized parameter - the degree of approximation to the limiting condition.

The optimization of the extraction conditions is attained by using criteria which characterize the importance of the decontamination factors, valuable component losses and internal accumulation of elements during reprocessing of different materials.

In conclusion, experimentally determined and computed static and dynamic characteristics of extractors are discussed.

c. Mass-transfer. The general regularities of mass-transfer are changed by the non-ideality of solutions and non-linearity of distribution isotherms (e.g. typical of extraction of actinides by TBP). The inconstancy of distribution coefficients does not permit to eliminate the interface concentrations from the expressions for diffusion flux by a simple procedure; in view of this the typical equation for mass-transfer becomes incorrect. A more general equation is deduced with the regard of the diffusion flux being proportional to the chemical potential gradient rather than to the concentration gradient. Some other possibilities of the elimination of interface concentrations are reviewed; mass-transfer data for extraction of uranium by TBP are interpreted. The discussion is given of some problems of hydrodynamics and mass-transfer from single drops and in the extractors as well as of the criteria facilitating the data correlation. The mechanism of extractor intensification is elucidated.

The effect of the longitudinal mixing and the transverse non-uniformity on the extractor efficiency is considered and the additivity limits of effects are established.

The possibilities of extractor calculation are discussed.